Dynamics of Coastal Conditions

Final Report

by

Hsiang Wang and Robert A. Dalrymple

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Department of Civil Engineering
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Newark, Delaware

Dynamics of Coastal Conditions

Final Report

A Summary of Research

Undertaken for The

Office of Naval Research, Geography Branch

Under Contract No. N0014-76-C-0342

by

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I. Introduction

This report summarizes the accomplishments of the research project, "Dynamics of Coastal Conditions", under Contract No. N0014-76-C-0342, supported by the Geography Program of the Office of Naval Research. The project covered the period from September 1, 1976 to August 31, 1980.

The research objectives were oriented toward developing predictive tools tailored to the Navy's needs. Specifically, the efforts were concentrated in three major tasks aimed at predicting coastal conditions:

1. Developing a nearshore circulation model,
2. Developing an onshore-offshore sediment transport model, and
3. Developing a shallow water wave transformation model.

During the course of research, various research tools including numerical modeling, laboratory studies and in-situ and remote-sensing field observations were employed.

Hsiang Wang and R. A. Dalrymple served as the principal investigators with the former as the project leader. Investigators at other academic and research institutions were also involved from time to time. Notably, a cooperative program was established between the Technical University of Braunschweig, Germany, and the University of Delaware. Dr. H. H. Dette and professor Alfred Fuhoboter have contributed to the project in organizing the German's research team who ably conducted the field experiments in 1976, 1978 and 1979. Dr. Tsuguo Sanumura then at Tokyo University (presently with the University of Tsukuba) participated in the laboratory experiments of onshore/offshore transport modeling as well as measurement of nearshore drift velocity.

Dr. Philip L. F. Liu of Cornell University worked with Dr. Dalrymple in developing nearshore circulation modeling.

II. Project Summary

1. Nearshore Circulation Modeling

Currents in the nearshore zone are induced by winds and breaking waves. Two numerical models have been developed under ONR funding to predict the flow near the coastline due to these forcing phenomena. The first, Birkemeier and Dalrymple (1976) was a linear model, not including the nonlinear convective acceleration terms, yet it provided a reasonably good estimate of flows caused by waves breaking over an irregular topography as determined by field experiments conducted by Argonne National Laboratory (Allender, Ditmars, Harrison and Paddock, 1978, Proc. 16th Coastal Engineering Conference, 1978). A more sophisticated model was developed by Ebersole and Dalrymple (1979) which included the convective acceleration as well as eddy viscosity/mixing terms. Results (Ebersole and Dalrymple, 1980) indicate that more realistic results are given by this model in regions where mixing or convection accelerations are important, such as in the vicinity of rip currents or longshore bars.

Kirby and Dalrymple (1982) have compared the results of both models to the field data obtained by the Nearshore Sediment Transport Study and have found that the models predict the natural flows reasonably well. The model (Ebersole and Dalrymple) will be undergoing a rigorous review in 1982 by the U.S. Army Coastal Engineering Research Center using data obtained from the Duck, N.C. Field Research Facility.

2. On/Offshore Sediment Transport Modeling and Breaking Wave Mechanics

The effort for this task spanned a four-year period. During this period, a number of topics, both of fundamental and practical importance, were researched with the ultimate goal of developing a user oriented on-offshore sediment transport model for the prediction of beach profile change under short but intense environmental events such as storms and hurricanes. More specifically, the research was carried out in the following order, although overlapping among subtasks were common:

A. Laboratory measurements were conducted to determine the fundamental mechanics of suspended sediment inside the surf zone as well as the flow characteristics inside the surf zone. Based upon the laboratory results, semi-empirical equations were proposed to describe the sediment and flow field conditions inside the surf zone.

B. A numerical model was developed on the basis of the results obtained in subtask A.

C. Laboratory and field measurements were then conducted to calibrate the numerical model.

The end product of this task includes a documented computer program and a series of reports and articles dealing with both the application of the model as well as various fundamental aspects of suspended sediment in surf zone and surf zone dynamics. These reports and articles are listed in Section III: Publications and Presentations.

3. Shallow Water Wave Environment

In this task, a numerical model was developed to predict wave spectral transformation from deepwater to shallow water. It is a finite difference model rather than the usual wave ray method. The finite difference model offers the advantage that it will provide the spatial distribution of shallow water spectra rather than a single point information provided by the wave ray method. The lateral energy spreading is more accurately handled as the finite difference method considers the balance over the complete region rather than between two wave rays that ignore the topographic effect outside the wave ray. More importantly, the effect of current on wave can be easily handled with the finite difference method. The model so far developed takes the following factors into consideration: (1) wave shoaling and refraction, (2) wave energy dissipation due to bottom friction, and (3) effects of current. A second generation model is now being developed which, in addition to the above factors, accounts for wave generation and unsteady state boundary conditions.

To verify and calibrate the model, field work was conducted at the Island of Sylt, Germany, in 1976, 1978 and 1979. In addition to measuring shallow water wave characteristics, other surf zone properties, such as suspended sediment transport, nearshore current and wave set ups, were also measured.

The product of this task includes a number of documented computer programs and reports and articles listed in Section III.

III. Publications and Presentations

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Tayfun, M. A., Yang, C. Y. and Wang, H., "Analysis of Inhomogeneous Wave Number Spectra", J. Geophys. Res., Vol. 80, No. 24, August, 1975.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report summarizes the accomplishment of the research project, "Dynamics of Coastal Conditions" for the period from September 1, 1976 to August 31, 1980. The efforts were concentrated in developing predictive models for: (1) nearshore circulation, (2) on/offshore sediment transport and (3) shallow water wave transformation. These numerical models were documented in respective reports listed.